Implementation of Wireless Networks in Rural Areas

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Abstract. This paper firstly reviews the rural condition, especially the channels of communication. Next, it examines the advantages of applying wireless technologies in rural areas. It presents two scenarios of wireless networking, with examples of implementation in Bario. In the first scenario, a wireless local area network (LAN) is set up and connected to a wired LAN using an access point. In the second scenario, a point-to-point wireless network is set up using two wireless bridges to connect two wired LANs. Both scenarios are viable to be implemented in rural areas.

Keywords. Wireless, Networks, Rural areas.

1. Introduction

Rural areas and smaller cities encounter limited telecommunications infrastructure, especially those which are geographically remote and isolated (Bala et al., 2000). In addition to the common channels of communication such as face-to-face and written communication, rural people and visitors moving in and out of a rural area is another important source of information (Bala et al., 2000). In recent years, radios and televisions have become increasingly important channels of information, but they are limited to one-way communication, where there is no interaction (Bala et al., 2000). Of late, another important communication channel in rural areas in recent years is the Very High Frequency (VHF) radio telephone service (Bala et al., 2000). Very Small Aperture Terminals (VSATs) are also used to link to satellites to provide Internet access, public telephone service and fax lines to certain rural areas (Unimas, 2004).

2. Advantages of Wireless Networking in Rural Areas

With the provision of Internet access via satellite links in rural areas, there are two alternatives of networking in rural areas, namely wired networking and wireless networking. However, wireless networking provides various advantages in rural conditions. First, in rural areas with scattered populations, using wireless networks can save the high cabling cost of the wired alternative. Secondly, wireless networks can ease installation in situations that are difficult-to-wire, for example when rivers, roads or other obstacles separate the facilities to be connected. Besides that, it can also reduce installation time, where installation of cabling is often a time-consuming task. Moreover, wireless networks also offer the benefit of increased reliability, where a frequently occurring problem faced by wired networks is the system downtime due to cable faults. Another primary advantage of wireless networks is that wireless networks support portability, which in turn allows greater flexibility when relocating, and mobility. In this paper, we provide two scenarios whereby wireless networks are employed in a remote rural community.

3. Scenarios of Wireless Networking: Examples of Implementation in Bario

Bario is a small and remote village in Sarawak, Malaysia. It is located on the Kelabit Highlands in the Borneo interior. Since the wireless alternative shows merits over the wired counterpart, two possible scenarios of wireless networking in rural areas are discussed with examples of implementation in Bario.

3.1. Scenario 1: wireless LAN

In this scenario, a wireless LAN is set up and connected to an existing wired LAN using an access point as an extension to the wired LAN. The wireless LAN can then share resources on the wired LAN, and vice versa.

3.1.1. Problem

The Bario community telecentre houses ten personal computers (PCs) intended for use by the community to access the Internet as well as to use software such as word processors and spreadsheet. It is located in a corner unit in a single-storey building and is connected to the Internet via a VSAT satellite link. The Bario clinic is situated on a hill about 100m away from the telecentre. At the clinic, a stand-alone PC is placed in a room with a window facing the telecentre. The clinic needs to be connected to the telecentre and the Internet as well.

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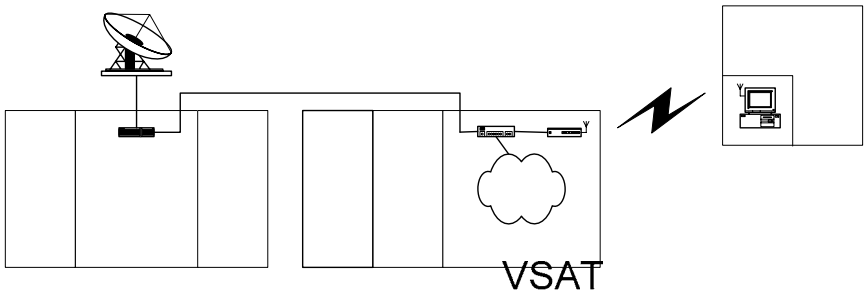

Figure 1. Wireless LAN at the telecentre and the clinic

3.1.2. Solution

An access point is installed at the telecentre to set up a wireless LAN at the telecentre, where the coverage area of the wireless LAN includes the clinic. The wireless LAN is also connected to the existing wired LAN at the telecentre via the access point. The PC at the clinic is installed with a wireless Peripheral Component Interconnect (PCI) Network Interface Card (NIC) to become a wireless client station. Thus, the wireless client station at the clinic on the wireless LAN is connected to the wired LAN at the telecentre and also to the Internet.

The equipment used to set up the wireless LAN includes a Cisco Aironet 350 Series Access Point at the telecentre and a Cisco Aironet 350 Series Client Adapter at the clinic. These Cisco Aironet products used are IEEE 802.11b standard-compliant. They are based on the Direct Sequence Spread Spectrum (DSSS) technology, operate in the 2.4-GHz Industrial, Scientific, and Medical (ISM) license-free frequency band, and support data rates of up to 11 Mbps. The access point used is of the standard version with two integrated 2.2-dBi dipole antennae. The client adapter is a PCI NIC and is also equipped with a 2.2-dBi dipole antenna. The range of the access point with the 2.2-dBi dipole antennae is approximately 40 to 610 m, depending on the environment and any obstacle that can interfere with the radio waves (Cisco, 2004). As the distance between the access point and the wireless client station increases, the data rate supported will decrease from 11 to 5.5, 2 and finally 1 Mbps within the coverage range of the access point.

The access point installed at the telecentre is connected using a Category 5 unshielded twisted-pair (UTP) patch cord of approximately 10 m to the wired LAN at the telecentre. It is mounted on the wall at a location that ensures coverage with good link quality for the wireless client station at the clinic. The client adapter is installed on the PC at the clinic to become a wireless client station, as stated. After installing the access point and the client adapter, a link test is run using Cisco's Aironet Client Utility (ACU) tool to determine the quality of the radio link between the access point and the wireless client station. The results obtained show that the wireless client station is connected to and associated with the access point with good radio link quality.

3.1.3. Evaluation

The wireless LAN is functioning well and the previously stand-alone PC at the clinic is now connected to the telecentre as well as the Internet. Thus, the clinic staff is able to access the Internet for medical information and for exchanging information with staff from other clinics and hospitals in the state, as well as access the shared resources on the wired LAN at the telecentre.

This scenario saves the cost and time of installing cabling from the telecentre to the clinic, which will otherwise be required if the wired alternative is implemented. In the future, when more PCs are added to the clinic, the PCs need only to be installed with a wireless PCI NIC each, to be connected to the wireless LAN, the wired LAN at the telecentre and the Internet. Again, the cost and time of installation of cabling can be saved.

3.2. Scenario 2: point-to-point wireless network

In this scenario, a point-to-point wireless link or network is set up using a pair of wireless bridges, to connect two existing wired LANs. Each of the wireless bridges is connected to a different wired LAN. As a result, the two wired LANs can share resources with each other.

3.2.1 Problem

The computer laboratory at Sekolah Kebangsaan (SK) Bario, a primary school in Bario, is located around 250m away from the Principal's room of Sekolah Menengah Kebangsaan (SMK) Bario, a secondary school in Bario. Both schools are separated by a field and a corridor outside the Principal's room. The computer laboratory at SK Bario is a corner room on the ground floor of a double-storey building. The Principal's room and the computer laboratory at SMK Bario are located in the same, single-storey building, where the Principal's room is a corner room a few doors away from the computer laboratory at SMK Bario, as illustrated in Figure 2. The wired LAN in the computer laboratory at SMK Bario is connected to the Internet via another VSAT satellite link. The stand-alone wired LAN in the computer laboratory at SK Bario is to be connected to the wired LAN at SMK Bario and to the Internet as well.

3.2.2. Solution

Two wireless bridges are installed, one at SK Bario and the other at SMK Bario, to set up a point-to-point wireless network to connect or bridge the wired LAN at SK Bario and that at SMK Bario into a single LAN. That is, one of the wireless bridges is connected to the wired LAN at SK Bario, and the other is connected to the wired LAN at SMK Bario. Thus, the wired LAN at SK Bario is connected to that at SMK Bario and also to the Internet.

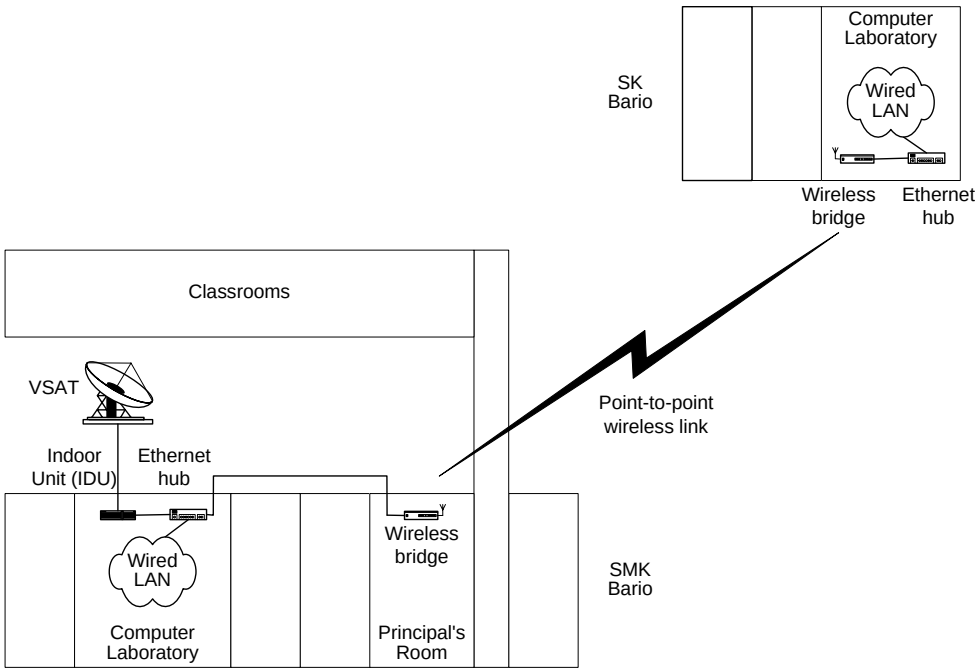

Figure 2. Point-to-point wireless network between SMK Bario and SK Bario

In this scenario, two Cisco Aironet 340 Series Wireless Bridges, each equipped with a 2.2-dBi removable dipole antenna, are used to set up the point-to-point wireless network. They are also IEEE 802.11b standard-compliant, and their range is also the same as that of the Cisco Aironet 350 Series Access Point in Scenario 1 since the antennae used are also 2.2-dBi dipole antennae.

With regards to the steps taken in the installation, first, at SMK Bario, one of the wireless bridges is installed in the Principal's room, and connected using a Category 5 UTP patch cord of approximately 30 m to the wired LAN in the computer laboratory. The wireless bridge is configured as the root unit between the two wireless bridges, since it is connected to the wired LAN that has Internet access. In the Principal's room, the wireless bridge is placed on top of a cupboard near to a window facing SK Bario.

Then, at SK Bario, the other wireless bridge is installed in the computer laboratory, and connected using a Category 5 UTP patch cord of about 10 m to the wired LAN in the computer laboratory. In contrast to the root unit, this wireless bridge is configured as the remote unit, and is mounted on the wall in the computer laboratory. Subsequently, the quality of the radio link between the two wireless bridges is determined by running a link test using the link test command contained in the console system of the wireless bridges. The results obtained show good link quality. Thus, the formerly stand-alone wired LAN at SK Bario is now not only connected to the wired LAN at SMK Bario but also to the Internet.

3.2.3. Evaluation

The point-to-point wireless network functions well, and the wired LAN in the computer laboratory at SK Bario is successfully connected to that at SMK Bario, as well as to the Internet. The teachers and students of SK Bario are able to access educational information from the Internet for teaching and learning purposes, as well as access the shared resources on the wired LAN at SMK Bario. They can also communicate and exchange information with their families, friends and others outside Bario or around the world easily. This scenario saves the cost and time that will otherwise be needed in the installation of cabling from SMK Bario to SK Bario, if the wired alternative is implemented.

4. Cost Consideration

The main reason why wireless technologies are employed in the two scenarios for Bario is the potentially high costs of setting up wired connections. These costs would include the costs of the cables, as well as the laying of the cables. Furthermore, the cost of flying all the equipment into Bario could be prohibitive. In contrast, wireless networks are relatively low cost to be set up in the two scenarios. For further information, the cost of the wireless network equipment used in the two scenarios is shown in Table 1.

Table 1. Wireless network equipment used in the two scenarios for Bario

Item	Unit	Unit Price (RM)
Cisco Aironet 340 Series Wireless Bridge	2	6150
Cisco Aironet 350 Series Access Point	1	3987
Cisco Aironet 350 Series PCI Client Adapter	1	1134

5. Conclusion

In scenario 1, a wireless LAN is set up to connect the stand-alone PC at the clinic to the wired LAN at the telecentre as well as the Internet. The equipment used is an access point installed at the telecentre, and a wireless client adapter installed on the PC at the clinic. In scenario 2, a point-to-point wireless network is set up to connect the wired LANs at SK Bario and at SMK Bario. The two wired LANs are connected using two wireless bridges installed at the two schools. Thus, the formerly stand-alone wired LAN at SK Bario is connected to the wired LAN at SMK Bario as well as the Internet. Both wireless networks function well and appear viable in the two scenarios. The clinic staff, and the teachers and students of SK Bario can thus benefit from the application of wireless technologies.

6. References

Bala, P., Khoo E., Songan, P., & Harris, R. (2000). Potential users profile and existing communication pattern among the rural community of Bario: A need analysis for the development of a telecentre. In M. Leigh (ed.), *Proceedings of the 6th Biennial Borneo Research Conference* (pp 626-648). Kuching.

UNIMAS (2004). *e-Bario Homepage: Strategy*. Retrieved April 5, 2004, from http://www.unimas.my/ebario/Strategy_index.htm

Cisco Systems, Inc. (2004). *Data Sheet: Cisco Aironet 350 Series Access Points*. Retrieved April 5, 2004, from http://www.cisco.com/en/US/products/hw/wireless/ps458/products_data_sheet09186a008009247c.html